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A LEXIS-SURFACE ANALYSIS**

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MARRIAGE AND FERTILITY IN CHINA: A LEXIS-SURFACE ANALYSIS

Zeng Yi, James W. Vaupel and Anatoli I. Yashin

Introduction

Patterns of marriage and fertility in China have changed rapidly over the last three decades. Fertility has dramatically declined, especially before age 20 and after age 30. Marriage remains virtually universal, but the age of first marriage, previously concentrated between ages 16 and 20, has shifted upward to between ages 20 and 25. These trends were sharply punctuated by marriage and fertility booms and slumps associated with the disturbances of the Great Leap Forward and the Cultural Revolution. Thus, strong age, period, and cohort fluctuations, some transient and others persistent, interact to produce a complex mosaic of turbulent demographic change.

Coale¹ masterfully analyzed these patterns of change. Here we supplement Coale's analysis by presenting and discussing some shaded contour maps of various surfaces of Chinese marriage and fertility rates. As discussed in detail elsewhere², such maps permit visualization of population surfaces defined over age and time and offer a panoramic view of the interaction of age, period, and cohort variations. Because the use of shaded maps of population surfaces is implicit in one of Lexis' original diagrams³, and because the term Lexis surface is increasingly being used to refer to surfaces of demographic rates defined over age and time⁴, the shaded contour maps presented here might be called Lexis maps.⁵ An early in-

¹Ansley J. Coale, *Rapid Population Change in China, 1962-1982*, Washington, D.C.: National Academy Press, 1984.

²J.W. Vaupel, B.A. Gambill, and A.I. Yashin, "Contour Maps of Population Surfaces", International Institute for Applied Systems Analysis, WP-85-47, August 1985; see also G. Caselli, J.W. Vaupel, and A.I. Yashin, "Mortality in Italy: Contours of a Century of Evolution", forthcoming in *Genus*, 1985.

³W. Lexis, *Einleitung in die Theorie der Bevölkerungsstatistik*, Strasbourg: Trubner, 1875, and "La représentation graphique de la mortalité au moyen de points mortuaires", *Annales de Démographie Internationale*, IV, 1880, pp. 297-324. The relevant diagram and accompanying text are presented in J. and M. Dupaquier, *Histoire de la Démographie*, Paris: Perrin 1985, pp. 388-9.

⁴W.B. Arthur and J.W. Vaupel, "Some General Relationships in Population Dynamics", *Population Index*, 50(2):214-226, Summer 1984.

stance of the use of contour maps (without shading) may be found in Delaporte's pioneering comparison of trends in age-specific mortality rates in various European countries.⁶

The data used to construct the Lexis maps are from China's one-per-thousand fertility survey conducted in 1982; the total sample size was a bit more than one million. The principle information gathered in the survey, which covered all of China except Tibet, Hongkong, and Taiwan, comprised detailed marriage and fertility histories of more than 300 thousand women aged 15 to 67, gathered through face-to-face interviews.⁷ This information was then used to reconstruct the pattern of age-specific fertility rates in China from 1940 through 1981 and the pattern of age-specific first-marriage rates from 1950 through 1981. For both fertility and first-marriage rates, an urban vs. rural breakdown was also published for 1950 through 1981.⁸

Coale and several other analysts⁹ have scrutinized the quality of the data and conclude that the data are reasonably reliable and give a generally accurate representation of the evolving age-specific patterns of Chinese marriage and fertility. Coale used the survey data to construct a set of estimates of age-specific proportions of women ever married. We use these estimates, but otherwise the maps we present are based directly on the original data.

⁵The computer program used to produce the maps was dubbed LEXIS by its designers, Bradley A. Gambill and James W. Vaupel. For information about the program, which runs on an IBM PC, please write to the Population Program, International Institute for Applied Systems Analysis, Laxenburg, Austria, or to J.W. Vaupel, University of Minnesota, USA.

⁶P. Delaporte, *Evolution de la mortalité en Europe depuis l'origine des statistiques de l'Etat civil*, Paris: Imprimerie Nationale, 1941.

⁷Yu Wang and Xiao Zhenyu, "General Introduction to the National One-per-Thousand Population Sample Survey of Birth Rates and an Initial Analysis of the Data Concerned", *Population and Economics*, special issue 1983, pp. 3-9. See footnote 8 below.

⁸The data were published in 1983 in a special issue of the Chinese journal *Population and Economics*. This issue includes a preface and 27 articles describing various aspects of the survey and data. An English translation was published as "Analysis of China's One-per-Thousand Fertility Sampling Survey", Beijing: China Population Information Office, 1984.

⁹J. Caldwell and K. Srinivasan, "New Data on Nuptiality and Fertility in China", *Population and Development Review* 10(1):71-79, 1984; J. Banister, "Analysis of Recent Data on the Population of China", *Population and Development Review* 10(2):241-271, 1984; G. Calot, "Données nouvelles sur l'évolution démographique chinoise: II. L'évolution de la fécondité, de la nuptialité, de l'espérance de vie à la naissance et de la répartition urbaine/rurale de la population", *Population* 39(6):1045-62, 1984; Pi-Chao Chen, "China's Other Revolution: Findings from the One in 1,000 Fertility Survey", *International Family Planning Perspectives* 10(2):48-57, 1984.

Marriage Since 1950

Figure 1 presents a shaded contour map of female first-marriage rates by single year of age from 15 through 35 and by single year of time from 1950 through 1981. The rates are unconditional: the numerator is the number of women getting married, the denominator is the total number of women that age. As indicated in the key, ten levels of marriage rates are distinguished, with a contour line at 1 percent and additional lines from 2.5 percent to 20 percent at intervals of 2.5 percent. Note that the scale on the key refers to the contours lines that separate different levels of grey, not to the levels of grey themselves. Thus the lightest area on the map represents periods when marriage rates were less than one percent, whereas the darkest area represents periods when marriage rates exceeded twenty percent. The rectangular patterns on the map result from the nature of the underlying data—single year of age and time; whatever diagonals appear are estimated by the algorithm used in the computer program. The tick marks on the axes are placed at the center of the appropriate year of age or time.

In learning to read the maps, it may be helpful to note that more than 20 percent of all 18-year-old women in 1962 and of all 23-year-old women in 1981 got married. Also note the trend in the contour line that starts at age 23 in 1951 and drifts upward to age 28 by 1979; above this line fewer than 2.5 percent of women, at each year of age and time, get married.

The most striking pattern on the map is the shift upward in age of first marriage. That such a shift has occurred is well-known: Zhao Xuan¹⁰, for instance, calculated average age at first marriage as 19.0 in the 1950's, 19.8 in the 1960's, 21.6 in the 1970's, and 22.8 in 1980-82. The Lexis map in Figure 1 gives a rich representation of the nature of the shift.

It is apparent from the map that marriage in China is concentrated in a short period of age. Consider, for example, the ages when female first marriage rates exceed ten percent. The period of high marriage rates shifted from ages 16 through 19 in the early 1950's to ages 18 through 21 around 1970 and to ages 20 through 25 around 1980. As a result of this shift, the proportion of women getting married at age 17 fell from close to 20 percent in 1950 to about 2 percent around 1980, whereas the proportion getting married at age 23 rose from 2 percent to over 20 percent.

¹⁰ Zhao Xuan, "State of Women's First Marriage in Forty-Two Years from 1940 to 1981", *Population and Economics*, special issue 1983, pp. 98-108.

riage had shifted upward by four years or so: before 1970 the peak age of first marriage was under age 20; after 1980 the peak was reached at age 23.

The marriage rates presented in Figure 1 are unconditional rates that give the proportion of all women of a certain age in a specified year who got married. Such rates are useful in analyzing the age pattern of marriage. For other purposes, however, it may be more informative to examine conditional marriage rates that give the proportion of unmarried women who marry. We calculated estimates of conditional first-marriage rates by dividing the unconditional rates by an estimate of the proportion of women who were not married; we took this denominator to be one minus Coale's age-specific, period-specific estimate of the proportion ever married. Figure 2a presents a Lexis map of the results.

The map is rather noisy, presumably because of various errors and random fluctuations in the underlying data. The noise is especially severe after age 30, because so few women are unmarried and so few marriages occur after this age. To reduce the noise, we smoothed the map over a three by three square.¹¹ The resulting map is presented in Figure 2b.

The darkest areas on the two maps represent ages and times when more than sixty percent of the unmarried women got married. The tremendous spurt in marriages in 1980 and 1981 of women in their mid-twenties who had delayed marriage is marked by a prominent black splotch. Among the cohort of women born in 1955, more than sixty percent of those who were still unmarried in 1980 (at age 25) got married and more than sixty percent of the remainder got married in 1981: more than ninety percent of the women who were not married at the start of the two year period were married by the end of it.

It is interesting to follow the contour line at the 10 percent level. Above this line, more than a tenth of the unmarried women get married each year; indeed, because the 20 percent and higher contour lines run only a few years higher than the 10 percent line, the 10 percent line can be viewed as representing the start of a period of intense marriage activity during which virtually all Chinese females become married. On Figure 2a, the 10 percent line starts at age 15 in 1950 and gradually rises to age 21 in 1977 before falling off to age 19 in 1981. This recent de-

¹¹We used binomial smoothing such that each value on the Lexis surface was replaced by a weighted average of itself and adjacent values. The value itself was given a weight of one quarter, the four horizontally and vertically adjacent values a weight of one eighth, and the four diagonally adjacent values a weight of one sixteenth. Along edges and in corners, the same relative weights were applied to the available data values, such that the sum of the weights totalled one. For further details, see Vaupel, Gambill, and Yashin *op. cit.*

cline can be attributed to the New Marriage Law, which was announced in 1980 and officially enforced from January 1, 1981. Earlier, local authorities placed various restrictions on the marriage of females before age 23. The new law permits women to marry after age 20.

Comparison of Figures 1 and 2 reveals some interesting differences between the patterns of unconditional and conditional marriage rates. Since the conditional rates equal the unconditional rates divided by the proportion never married, the conditional rates have to be higher than the unconditional rates. Nonetheless, it is somewhat startling how much higher they are, especially at older ages. The durable pattern of universal marriage in China implies that women in their late twenties who are not married as yet have a high chance of getting married. Consider age 25 through 28, for instance. A swath of dark shades runs across Figures 2a and b, indicating conditional marriage rates ranging from 20 percent to above 60 percent, averaging about 40 percent per year. For every cohort shown on the map, at least ninety percent of the women who were not married at age 25 got married by the end of age 28.

Cohort patterns along diagonals are more apparent in Figure 2a than in Figure 1 (or smoothed Figure 2b). There is, of course, an overwhelming cohort effect in that virtually everyone marries: since the unconditional marriage rates thus sum along cohort diagonals to a number close to 100 percent, if the rates are low in some years they have to be higher in other years. But this kind of effect, because it is compensatory rather than persistent, does not show up on a Lexis map as a strong diagonal pattern. The conditional marriage rates depicted in Figure 2, on the other hand, can follow persistently high or low trajectories.

Consider, for instance, the two cohorts that were age 20 in 1968 and in 1971. The first cohort experienced conditional marriage rates above 30 percent per year until age 25 and above 40 percent per year from age 25 to 32. The second cohort, in contrast, experienced conditional marriage rates below 20 percent at ages 20 and 21 and below 30 percent at every other age except ages 25 and 26. This striking difference is probably attributable to the effects of the family planning program implemented after 1970, which emphasized late marriage. The women who reached at age 20 in 1968 were old enough in subsequent years to meet the requirements for late marriage, defined in most areas as marriage at age 23 or later; the women who reached age 20 in 1971, on the other hand, were strongly influenced by the emphasis on delayed marriage.

Figures 1 and 2 provide somewhat different perspectives on the effects of period events and trends, the smoothed map in Figure 2b providing a somewhat clearer picture than the noisier map in Figure 2a. The slumps in marriage around 1959 as a result of the Great Leap Forward and concomitant famine and the subsequent slumps in the mid 1960's and mid 1970's are clearly reflected in the smoothed conditional rates, as are the marriage booms of the 1950's, early and late 1960's, and early 1980's. Figure 2b also reveals the catch-up behavior of cohorts that have experienced low marriage rates: note in particular the marriage sloughs followed by marriage peaks along the diagonals starting at age 20 around 1960, 1965, and 1975. Also note on Figure 2b the narrowing over time of the period of high conditional rates of marriage: From 1952 to 1954, unmarried women in the eleven year period from age 19 through age 29 had a 30 percent or greater chance of marriage per year. In 1979 to 1981, on the other hand, this period of intense marriage activity was concentrated in the six years from age 23 through 28.

Figure 3 presents a Lexis map of Coale's estimates of the proportion of women ever married from ages 15 to 35 from 1950 to 1982. The sharp shift upward in age of first marriage is vividly revealed by the map. In 1950, fully half of Chinese women were married by age 18 and 90 percent by age 22. In 1982, the median age of first marriage had increased to age 22 and the 90 percent level was not reached until age 26. The map also shows the continuing concentration of marriage within a few years of age. In 1950, half of all first marriages occurred at ages 17, 18, and 19; in 1982, half occurred at ages 20 through 23.

The near universality of marriage in China is evident on the map. For every cohort more than 97.5 percent of the women were married by age 35, and for most of the cohorts the total exceeded 99 percent. The cohorts for which more than one percent (but less than 2.5 percent) of the women were unmarried by age 35 were the cohorts 20 years old in 1955-6, 1958-9, 1962, and 1975; these cohorts may have been especially severely affected by the disturbances of the 1957 "movement against the right wing", the Great Leap Forward in 1959-61, the Cultural Revolution in the mid 1960's, and the mobilization of many school graduates to go to mountain and rural areas in the late 1960's and early 1970's. It is somewhat puzzling, however, that adjacent cohorts were not similarly affected. Detailed examination of the impact of external events on cohorts may shed light on this, but the explanation may lie in stochastic fluctuations or sampling errors. What is perhaps most remarkable is that despite the various crises from 1957 through the early 1970's, which disrupted many young people's marriage and career plans, nearly all Chinese females continued to get married.

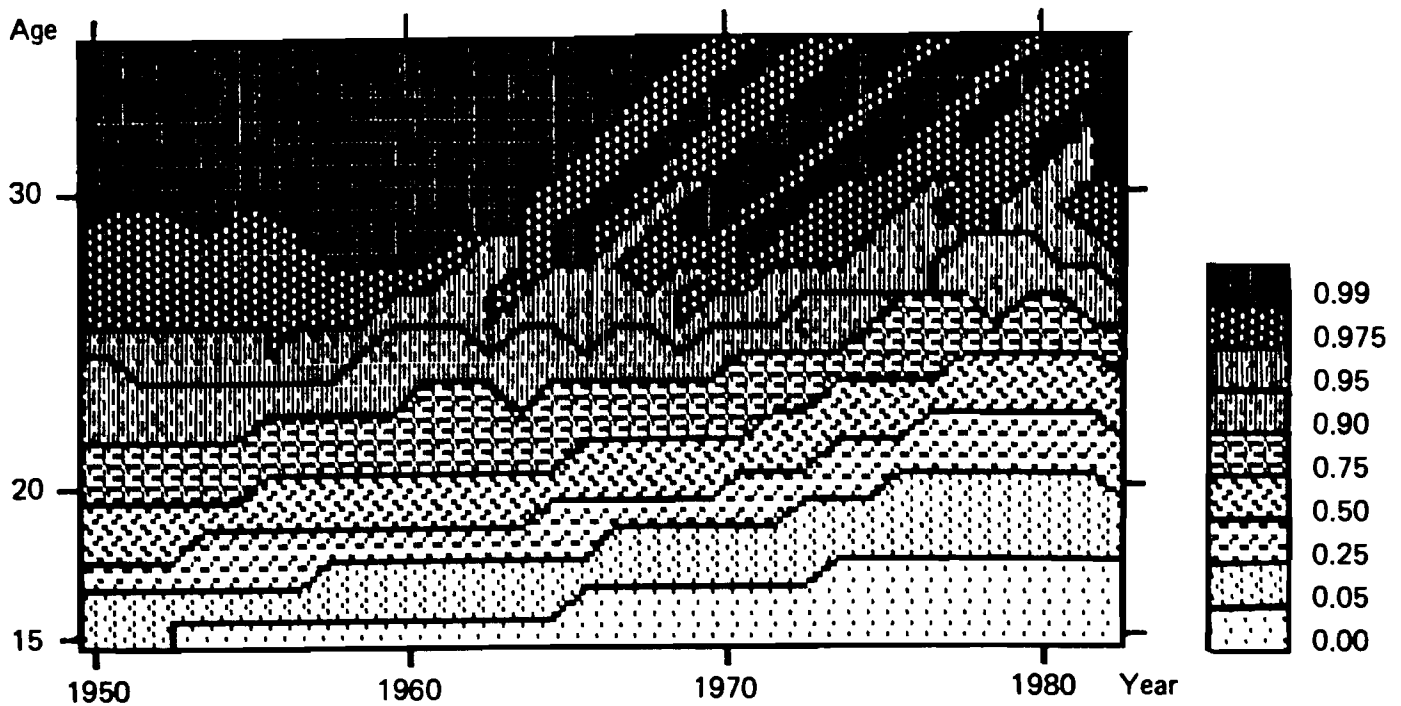


Figure 3. Proportion ever-married, females age 15-35, China, 1950-1982.

Fertility Since 1940

Figure 4 presents a Lexis map of Chinese fertility rates by single year of age from 15 to 49 and from single year of time from 1940 to 1981. The map is on the same scale as the previous maps: it is bigger because the age and time axes are longer. The fertility rates are defined as the number of women who gave birth at age x in year t divided by the total number of women of that age at that time.

The most striking feature of the map is the rapid decline in fertility after 1970. This decline is well known and often summarized by the dramatic drop in the total fertility rate: in 1970 the total fertility rate was 5.8; by 1981 it had fallen 55 percent to 2.6. What the map graphically reveals is the age pattern of decline. Consider the ages where the fertility rate exceeds 20 percent. In 1968, this period of high fertility stretched from age 20 through 37. By 1981, in contrast, the period of high fertility was concentrated from age 23 to 27. In 1968, more than 20 percent of 20-year-olds and more than 10 percent of 40-year-olds gave birth. By 1981, the fertility rate of 20-year-olds had fallen under 10 percent and the fertility rate of 40-year-olds had fallen under 2 percent. The precipitous decline in

the fertility contours at older ages and the marked increase in the contours at younger ages reflect the success of Chinese birth control policy, including the increase in age of first marriage and, even more importantly, the widespread use of contraception.

The radical narrowing of the period of high fertility was slightly reversed in 1981 and there is some evidence of an increase in births among 25 and 26 year-old women. This is undoubtedly a result of the New Marriage Law announced in 1980 and the concomitant boom in marriages, especially among women in their mid-twenties.

The most conspicuous period disruption on the map is the trough in fertility in 1959-61. This coincides with the Great Leap Forward and corresponds to a similar trough in marriage rates, except that marriage rates tended to be lowest in 1959 whereas fertility rates reached their low point in 1961. The recovery of fertility rates from their depressed level in 1961 was dramatic: during the prolific ages between 23 and 29, fertility rates rose from under 20 percent per year in 1961 to over 30 percent per year in 1962 and over 35 percent per year in 1962.

The fertility data pertaining to earlier years, especially the years before 1950, have to be interpreted with caution since they are reconstructions based on interviews taken in 1982. The general pattern seems reassuringly plausible: over the course of the 1940's and 1950's fertility rates were fairly stable, with some tendency toward increase. This is consistent with trends in improvements in living standards, and the absence of widespread contraception, during this period.

Because marriage almost inevitably precedes childbearing in China, and because there have been strong fluctuations in marriage rates by period and a marked upward shift in the age of first marriage, we conjectured that it would be informative to examine fertility rates for married women. We used Coale's estimates of proportions ever married to compute fertility rates among ever married women, a reasonable approximation in China to fertility rates among married women since divorce and widowhood rates are low and since there are relatively few widowed or divorced women who do not quickly remarry.¹² Figure 5 displays a Lexis map of the results. Note that the map runs from 1950 to 1981, rather than from 1940 to 1981, because marriage data were not available before 1950.

¹²See Coale, *op. cit.*, p. 55, and Y. Zeng, "Marriage and Marriage Dissolution in China: A Marital Status Life Table Analysis", Voorburg, the Netherlands: Netherlands Interuniversity Demographic Institute, Working Paper 57, 1985.

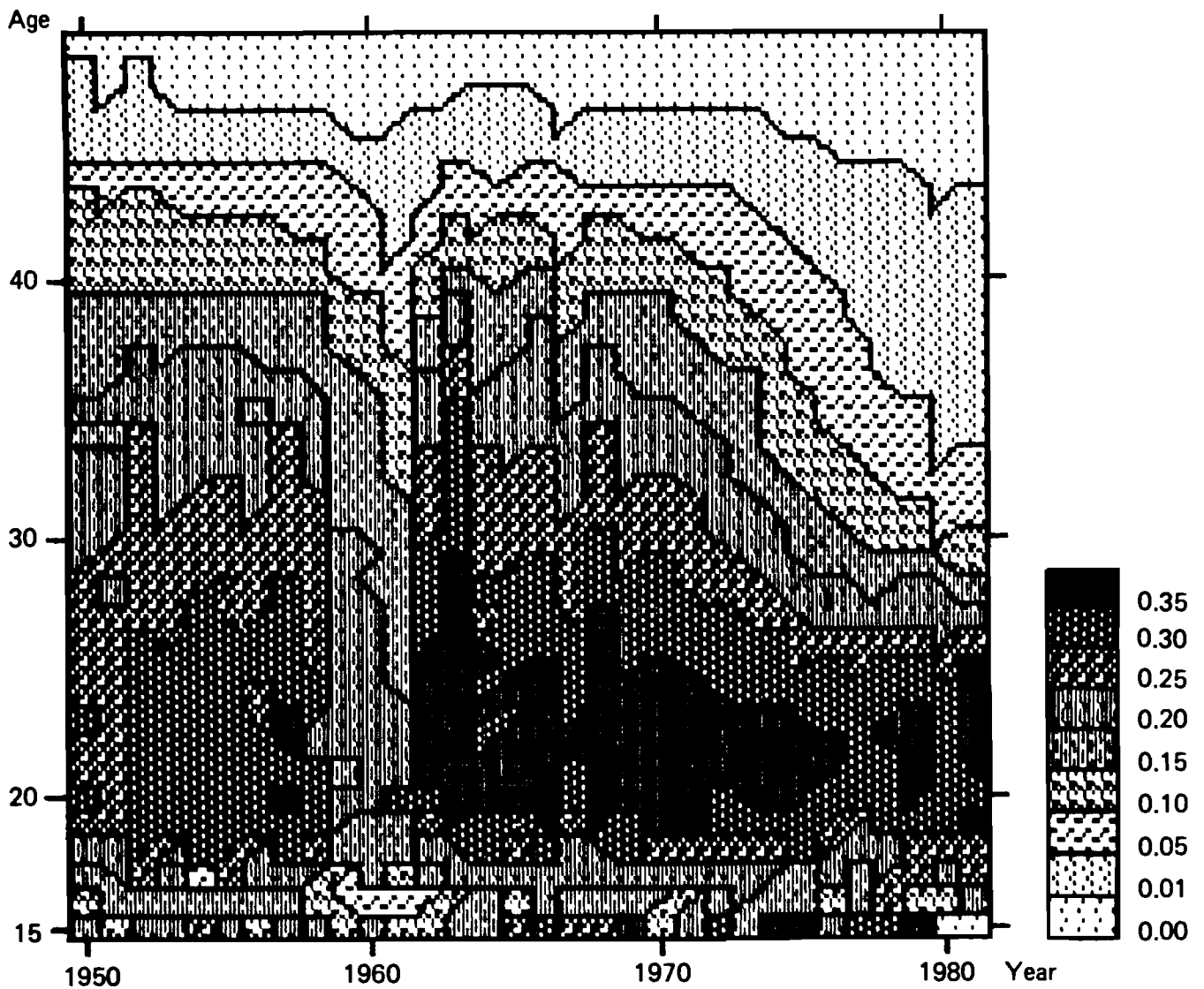


Figure 5. Fertility rates of ever-married women age 15-49, China, 1950-1981.

At older ages, the patterns in Figure 5 are similar to the patterns in Figure 4, as might be expected given the near universality of marriage in China by age 30 or so. The most striking difference between the maps in Figures 4 and 5 occurs below age 20: fertility rates are high among married women under age 20, but overall fertility rates are low at these ages because relatively few women are married.

Thus the decline in fertility before age 20 over the last three decades can be almost entirely attributed to the increase in age of first marriage.

The swath of black across the map in Figure 5, concentrated between ages 19 and 26 and especially prominent after 1962, reveals the very high levels of child-bearing among married women at these ages: fertility rates in this band are generally above 35 percent per year, even after the implementation of the family planning program—later, longer, fewer—in the early 1970's. The greater persistence of this band than the corresponding band in Figure 4 indicates the importance of fluctuations in marriage rates and the increase in average age of marriage in determining fertility rates not only before age 20, but also during the peak years between ages 20 and 26 or so. That is, the decline in fertility rates among women in their early twenties can also be largely attributed to the increase in age of first marriage.

Rural-Urban Differences

Roughly four-fifths of the Chinese population is classified as rural; the remaining fifth is urban. The differences between these two populations are so substantial that statistics were separately published on marriage and fertility rates for rural and urban areas.

Figures 6 and 7 present Lexis maps of rural and urban marriage rates. The maps are on the same scale as previous maps; note that age runs from 15 to 35 and time scale from 1950 to 1981. Because the rural population is 80 percent of the total population, the rural map is quite similar to the map of total marriage rates presented in Figure 1. The interest of the rural and urban maps lies in the striking differences between the rural and urban patterns.

The maps reveal that the upward shift in age of first marriage began earlier and has proceeded further in urban than in rural areas. In 1981 rural marriage rates reached nearly 20 percent per year at ages 20 through 23; urban marriage rates peaked at more than 20 percent per year at ages 23 through 25.

In the mid 1960's and mid 1970's, urban marriage rates fell much more than rural rates. In 1965, for instance, only at a single year of age, age 22, did urban marriage rates exceed 10 percent; whereas in rural areas, marriage rates were above 10 percent at age 20, above 12.5 percent at age 17, and above 15 percent at ages 18 and 19. This difference between rural and urban areas can be attributed, especially in the 1970's, to more successful family planning in urban areas. Con-

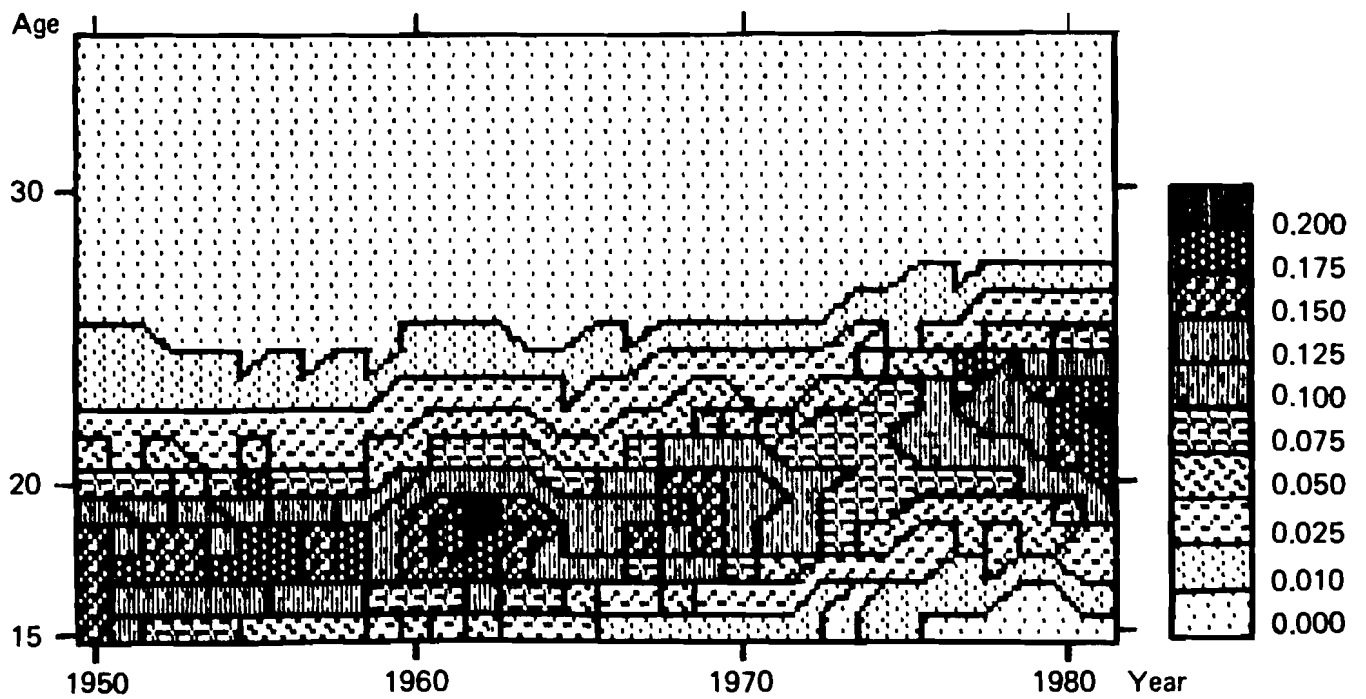


Figure 6. Rural first marriage rates, females age 15-35, China, 1950-1981.

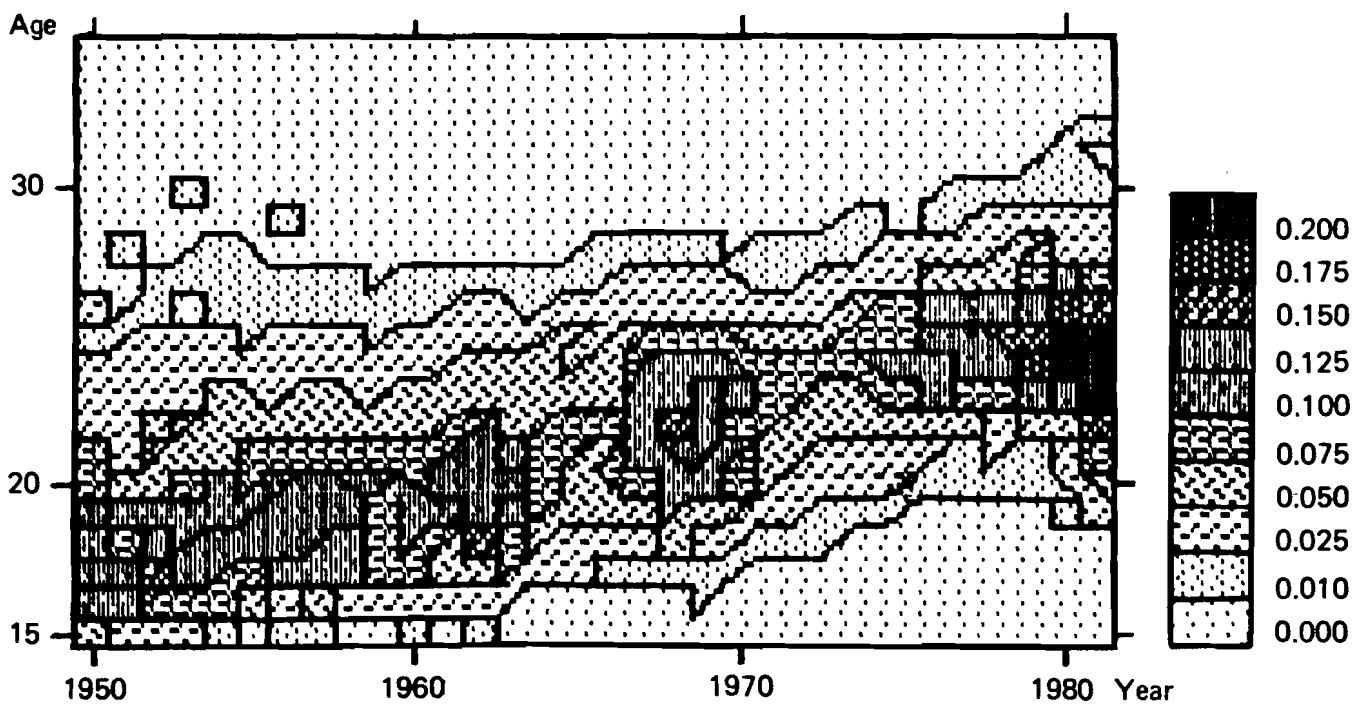


Figure 7. Urban first marriage rates, females age 15-35, China, 1950-1981.

versely, the New Marriage Law announced in 1980 seems to have increased urban marriage rates more substantially than rural marriage rates, urban rates rising above 20 percent per year in the peak ages of marriage and rural rates remaining below 20 percent per year at all ages. Restrictions by local authorities on marriage were especially pronounced in urban areas; the New Marriage Law in effect relaxed these restrictions by permitting women to marry after age 20.

As shown by the maps in Figures 8 and 9, patterns of fertility in urban and rural areas of China were roughly comparable in the 1950's. Indeed, during this decade total urban fertility fluctuated between 80 percent and 100 percent of total rural fertility. After 1960 the patterns sharply diverge, with urban fertility falling further and more rapidly than rural fertility. In the 1970's and early 1980's, total urban fertility was just under half of total rural fertility.

The biggest difference between urban and rural age patterns of fertility lies in the tendency for urban women to have children in their late twenties whereas rural women have children throughout their twenties. Since 1975, fertility rates above ten percent per year have been concentrated in urban areas between ages 25 and 28, whereas similarly high rates of rural fertility have been concentrated between ages 21 and 29. In both urban and rural areas there has been a radical decrease in childbearing above age 30 and a substantial decrease before age 20, although these patterns of decrease are apparent earlier and have proceeded further in urban areas.

Conclusion

Shaded contour maps of Lexis surfaces of Chinese marriage and fertility rates provide a useful supplement to standard modes of graphical presentation and analysis. The Lexis maps clearly and efficiently display both persistent global and prominent local patterns, simultaneously over age and time. The maps facilitate visualization and hence deeper comprehension of patterns that may have previously been only hazily understood. William Playfair, the pioneer of graphical methods for presenting statistical data, argued that with a good visual display "as much information may be obtained in five minutes as would require whole days to imprint on the memory, in a lasting manner, by a table of figures."¹³ The ten Lexis maps

¹³William Playfair, *The Commercial and Political Atlas*, 3rd edition, London: J. Wallis, 1801, p.xii, quoted in C.A. and S.E. Schmid, *Handbook of Graphic Presentation*, 2nd edition, New York: Wiley, 1974.

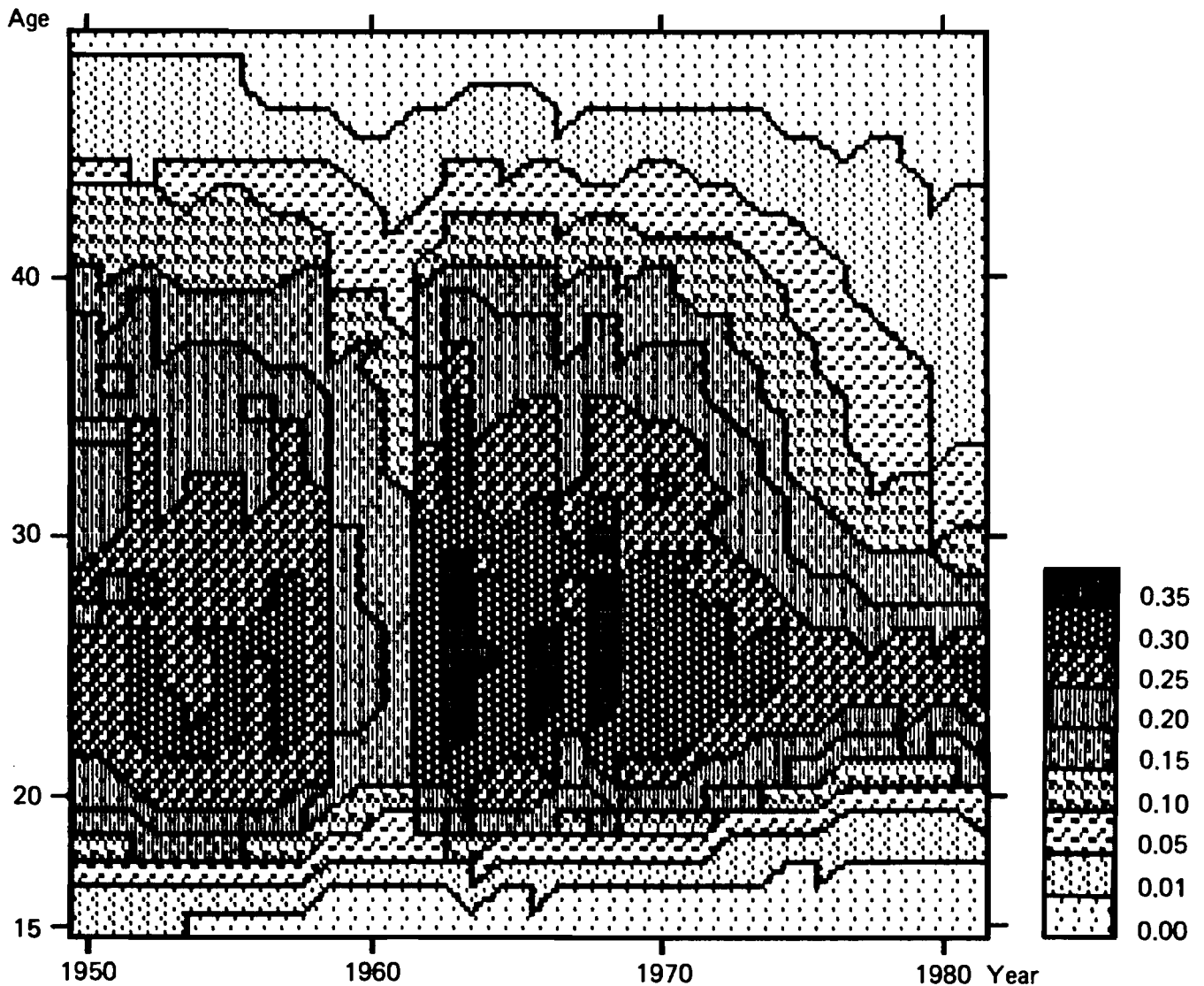


Figure 8. Rural fertility rates, females age 15-49, China, 1950-1981.

presented in this paper summarize more than 10,000 different numerical values in a memorable, revealing way.

The maps clearly display the long-term trends in Chinese marriage and fertility: age of first marriage has shifted upward by about four years and fertility has dramatically declined, especially before age 20 and after age 30. The maps also reveal the substantial impact of disruptions associated with the Great Leap Forward, the Cultural Revolution, and the mobilization of urban school graduates for

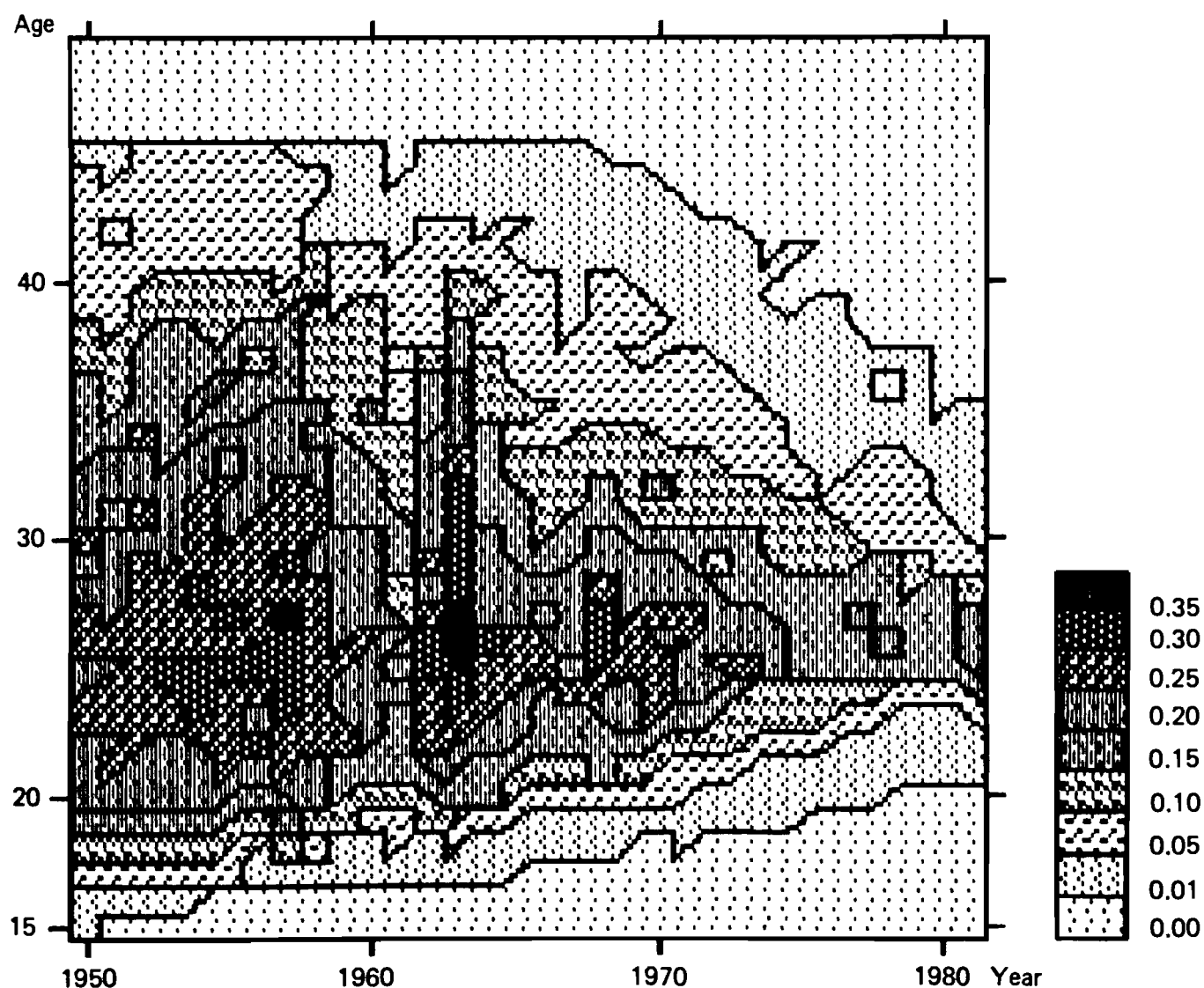


Figure 9. Urban fertility rates, females age 15-49, China, 1950-1981.

work in rural and mountainous areas, as well as the increase in marriage and fertility associated with the New Marriage Law announced in 1980.

Because the maps display age and time simultaneously, the effect of long-term trends and short-term disturbances on the age-composition of marriage and fertility can be readily seen. Marriage continues to occur largely within a five year period of age, although this period has shifted from 15-19 to 20-24. Childbearing has been drastically concentrated in the ages from 21 to 28, childbearing at

younger ages being reduced as a result of later marriage and childbearing at older ages being reduced by widespread contraception. Urban patterns are increasingly diverging from rural patterns, with later ages of first marriage and fertility, and fertility rates only about half as high as rural rates.

Amidst the turbulent change, two striking regularities persist. Marriage, although delayed, remains virtually universal by age 35, and fertility among married women younger than 26 remains as high as it has been over the last thirty or forty years. Indeed, between ages 19 and 26 about a third of married women bear a child each year.